Journal of Mechanical Engineering Research and Developments
ISSN: 1024-1752
CODEN: JERDFO
Vol. 44, No. 7, pp. 109-119
Published Year 2021

A Comparative Study of Edge Detection Techniques in Digital Images

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ABSTRACT

Digital image processing consists of the manipulation of images using digital computers. Its use has been increasing exponentially in the last decades. Everyone is concerned and demands a system as faster, more accurate, cheaper and more extensive computation. An image is defined as an array, or a matrix, of square pixels arranged in rows and columns. Image processing is a procedure of converting an image into digital form and carry out some operation on it, in order to get an improved image and to retrieve some important information from the image. It involves various steps like image analysis, image segmentation, edge extraction, image compression etc. In this paper, three essential edge detection methods , programmed to determine the best way in terms of accuracy and time, based on the alleged masks, i.e., arrays applied to the image sequentially is according to each mask , come up with a new image containing only the edges of the original image. These three methods are Sowell Method, Laplace Method and Robert Method. The outcome of applying these methods were , the best results obtained from the Laplace method because it highlights the shapes contours more clearly. Robert's approach is comparatively better than Sobel's edge detection methods.

KEYWORDS

Digital image processing , Methods, Sowell Method, Laplace Method, Roberts Method

INTRODUCTION

Digital image processing consists of the manipulation of images using digital computers. The discipline of digital image processing is a vast one, encompassing digital signal processing techniques as well as techniques that are specific to images[1]. To be processed digitally, it has to be sampled and transformed into a matrix of numbers. Digital image processing consists of the manipulation of those finite precision numbers. Usually, the image will be in the form of a matrix whose contents are two-dimensions; the contents will be either binary numbers If the picture is black and white or has grey gradients; else, if the picture is coloured, it will have different numbers [2]. The processing of digital images can be divided into several classes like image processing to reduce noise, contrast enhancement and image sharpening, Segmentation (partitioning an image into regions or objects) , Description of those objects to reduce them to a form suitable for computer processing , Classifications (recognition) of objects and Image analysis and computer vision, image restoration, image analysis, and image compression. Edge detection, slimming operations, description of the contents of the image, and understanding the shapes of the image[3].In digital image processing, edge detection plays an important role in image analysis and computer vision areas.The objectives of edge detection are to detect the shape information of the object and the reflectance in the image[4].The work aims to program important methods for edge detecting and to experiment on several images to obtain results through which we can know the characteristics and efficiency of these methods.

Image Processing

Visual information is the most important type of information perceived, processed and interpreted by the human brain. Digital image processing focuses on two major tasks:

– Improvement of pictorial information for human interpretation.
– Processing of image data for storage, transmission and representation for autonomous machine perception[1].

Digital image processing, as a computer-based technology carries out automatic processing , manipulation and interpretation of such visual information and it plays an increasingly important role in many aspects of our daily life as well as in a wide variety of disciplines and fields in science and technology as like in[2]:

• Computerized photography (e.g., Photoshop)
• Space image processing (e.g., Hubble space telescope images, interplanetary probe images)
• Medical/Biological image processing (e.g., interpretation of X-ray images, blood/cellular microscope images)
• Automatic character recognition (zip code, license plate recognition)
• Finger print/face/iris recognition
• Remote sensing: aerial and satellite image interpretations
• Industrial applications

The purpose of digital image processing is to improve or extract quantitative information that is not readily apparent to the eye, and to calibrate an image in photometric or geometric terms[5].

The Process of analysis using digital image processing can be divided into 4 basic phases.

Image Restoration

Restoration is a process that attempts to reconstruct or recover an image that has been degraded by using a prior knowledge of the degradation phenomenon. The purpose of image restoration is to "compensate for" or "undo" defects which degrade an image in many forms such as motion blur, noise and camera misfocus[2].

Image Enhancement

Image enhancement refers to the process of highlighting certain information of an image, as well as weakening or removing any unnecessary information according to specific needs. For example, eliminating noise, revealing blurred details, and adjusting levels to highlight features of an image. Digital image enhancement and analysis have played, and will continue to play, an important role in scientific, industrial, and military applications[6]. Often the enhancement of certain features in images is accompanied by undesirable effects. Valuable image information may be lost, or the enhanced image may be a poor representation of the original. Furthermore, enhancement algorithms cannot be expected to provide information that is not present in the original image. If the image does not contain the feature to be enhanced, noise or other unwanted image components may be inadvertently enhanced without any benefit to the user[7].

Image Compression

Image compression is the process of encoding or converting an image file in such a way that it consumes less space than the original file[8]. It is a type of compression technique that reduces the size of an image file without affecting or degrading its quality to a greater extent[9].

Image segmentation

It is the process of partitioning a digital image into multiple segments .The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze.Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images[10]. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics such as color, intensity, or texture[11].

Basic Concept of Digital Image

Vision is the most advanced of our senses, so it is not surprising that images play the single most important role in human perception. Digital image processing encompasses a wide and varied field of application. These images are called optical images, which represent their information in the form of analog electrical signals[12]. While images handled by computer must be converted to a digital format, digitization is done in both space and expansion events. This process is called digitization of space by sampling and digitizing the quantification in colored images. The method of quanization in colored images is done by choosing a combination of colors representingthe color’s chain of the image[13].

The images resulting from the digitization process are called Digital Image, a 2D light intensity function (x,y)f and represents a matrix of points in the form of columns and lines, and each of these points is called Picture Element and its abbreviation Pixel and is the smallest part of the image can be located within the image using the coordinate system (x,y) as shown in the equation (1-2) and each point has a numerical value representing gray level at that point and its value ranges from zero color black to A great value that depends on the ability to store the computer and represent the white color[2].

$$f(x,y) = \begin{matrix} f(0,0) & f(0,1) \ldots\ldots f(0,N-1) \\ f(1,0) & f(1,1) \ldots\ldots f(1,N-1) \\ f(N-1,0) & f(N-1,1) \ldots\ldots f(N-1,N-1) \end{matrix} \quad \ldots\ldots\ldots\ldots(1\text{-}2)$$

Computer Image System

Digital image processing systems consists of two basic modules: hardware and software[14].

The steel entity components can be represented by a catalyzing chart, as shown in *figure (1)*, which contains three basic elements (Image acquisition, Image processing, Image showing).

Figure 1. Basic components of the image processing system

Image Acquisition

The conversion of a scene image into a digital representation that computers can understand and processed, involves process that is produced using unique sensitive systems designed to see the viewer and then represent it digitally and convert television signals or photographs into digital representation sized into three types[15].

- Cameras
- Scanner
- Satellite

Image Processing

It is a method that develops to convert the image into digital form and perform some operations to obtain specific models or to extract useful information from it using complex processing steps that includes a number of multispectral image components and multi Sectral Image ClassiFication[12].

Image Display

In any image processing, there is an output device that shows the success or failure of the processing system, and this phase includes the generation of output that can be observed by humans where digital image data is converted into a visual analog such as video signals or a film product, where recording devices are divided into[1]:

- Monitors.
- Recorders
- Printers

As far as software is concerned, its primary function is to represent the image and perform the necessary processing of its data, as well as to control image collection and process its storage using different high-level software languages[16].

Image Data Types

There are many types of images that represent each element of the image, where they can be divided into:

• Monochrome image

It is the simplest type of image and takes only 0 or 1 as it is represented by 1Bit/Pixel, which is commonly used in computer vision systems applications [9].

• Gray Level Image

These images only have gloss levels, and the value of each element in the image gives the color gradient to that point, that the ideal number to represent each 8-Bit element with a gloss level of 0-255[17].

• Color Images

These images are represented by a model consisting of three monochrome data packets, and that each of these data is due to a basic color *(red, green, blue*), and using 8-bit for each color pack, the color image is 24-Bit per item as shown in figure (2)[18 a].

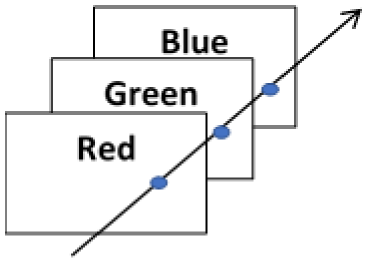

Figure 2. Basic color beams

The number of colors of a real-color image is as many as 16 million different colors since each basic color has a color gradient of 2 and a total of 3 (28) or 16,777.21; this amount of colors is limited by the possibility of the solid entity of the computer, but in general 256 different colors can be seen at the same time[9]. In many applications, RGB basic color information is converted to other sports space, which separates gloss information from color information for easier handling[15].

• Multi-Spectral Image

These images contain information beyond the limits of human perceptual perception where they contain data for infrared, ultraviolet, X-ray, or radar and are not the images of familiar scenes because the information they represent is not directly visible by the human eye. These images are satellites,different types of spacecraft-borne radars, infrared imaging systems, and medical diagnostic imaging systems[9].

RGB Basic Color Space

Color is a powerful descriptor that often simplifies object identification and extraction from an image. The most commonly used color space in computer vision technology is the RGB color space because it deals directly with the red, green, and blue channels that are closely associated with the human visual system.A color image with little light can be considered much better than a well-lit color image.The color images are usually given in the RGB system as they contain data equal to three times the data of non-colored images, i.e. color images as three noncolored images [R)x ,y), G(x,y), B(x,y)].Contains the same information but in different color tones[1]. The color's chain of this system is represented by a cube as shown in figure (3), and each color gives you a point either on the surface or inside the cube; the diameter of the cube gives grays colors ,it ranges from black R=G=B=0 to white R=G=B=Max[19].

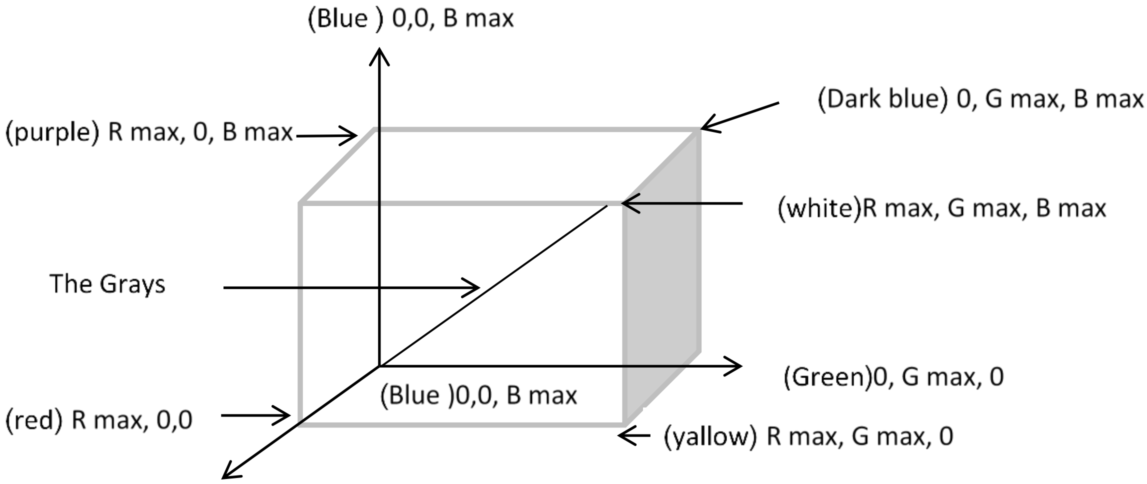

Figure 3. Color representation in RGB color space

The disadvantages of this system can be summarized as follows[11]:

1- The high correlation between its compounds make this space unsuitable for many image processing methods, the most important of which is compression.
2-. Its basic components cannot be understood by intuition or intuitiveness.
3- Heterogeneous, i.e., the impossibility of determining the difference between colors based on the differences in distance between them.

For these reasons, some international organizations have proposed a number of color coordinates to process color images.

Edge Detection Operator

Most of the shape information of an image is enclosed in edges. Edge highlights most of the characteristics of the objects in the image[17]. So first we detect these edges in an image and by using filters and then by enhancing those areas of image which contains edges, sharpness of the image will increase and image will become clearer.The process of identifying the edge is one of the techniques that we need to the process of cutting images [6]. The method of uncovering the edge of processes that are not affected by the location, size, and shape of the objects in the images, i.e., their results' efficiency is not affected.Some factors influence the process of uncovering the quilt, such as the boundaries of shapes and the mental vision of the form, i.e. the visualization of the shape in the human mind. The edge detection process's main objective is to detect the color changes in the image (i.e., to detect locations where different colors change, patterns of all kinds and backgrounds in their forms. This change refers to a color area, and the beginning of another area called an edge[20]. The edge detection process is based on the idea of edge information, which in turn depends on the relationships between each point and its vicinity, so if its proximity is similar to it, it does not form an edge. Otherwise, it forms an edge or part of the edge[9].

Traditional ways to detect the edge

Edge detections are classified into two directed and unguided types, and the difference between them is that the unoriented does not focus on the direction within the image. Simultaneously, the vector is very useful for edge detection cases and their characteristics with direction or directional parameters[21]. On the other hand, edge detections are classified into two categories (slope and laplus) of laplusedge detection methods looking for a zero-point intersection in the second derivative of the image[22].

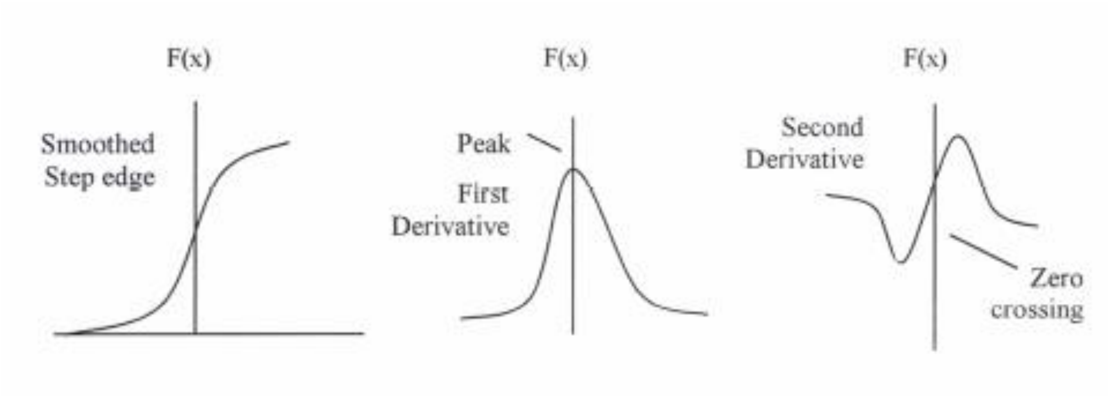

Figure 4. Represents the edge and with it the first and second derivative.

In the current research, we will apply different types of edge detections and various types of images as follows:

Operation Sobel (Sobel)

The two-dimensional Sobel process is applied to the image and focuses on the high-frequency area to detect the edges, and uses somewhat is absolute inclination (regression) at each point in the image and contains Sobel on a mask measuring 3*3, and as shown in figure (5), one represents the type (2-1), one represents the type of rotation with a score of 90 and each of them is called a kernel and these nucleus are designed for different horizontal, vertical and combined border suporals[23]. Sobel is slow as compared to Roberts, but it is comparatively better in terms of illustration and detection, less noise sensitivity, and generally higher than output relative to The Roberts process[13].

-1	-2	-1
0	0	0
1	2	1

-1	0	1
-2	0	2
-1	0	1

Figure 5. Represents a Sobel mask

Operation Roberts

The Roberts Cross operator performs a simple, quick to compute, 2-D spatial gradient measurement on an image. It thus highlights regions of high spatial frequency which often correspond to edges[24]. In its most common usage, the input to the operator is a grayscale image, as is the output. Pixel values at each point in the output represent the estimated absolute magnitude of the spatial gradient of the input image at that point[25]. The mask contains two nuclei, each measuring the first 2*2 simplified and the second rounded at a 90 degree angle as shown in figure (6). These intentions were formed or designed to respond to high degrees of rims with rotational degrees of 45 or 135 and even vertical ones, and applied separately to different images to extractregression in each direction and wimsi (Gy, Gx). By combining their actions at each point, we extract thetotal value[26]. The main reason for using the Roberts Cross operator is that it is very quick to compute. Only four input pixels need to be examined to determine the value of each output pixel, and only subtractions and additions are used in the calculation. In addition there are no parameters to set. Its main disadvantages are that since it uses such a small kernel, it is very sensitive to noise. It also produces very weak responses to genuine edges unless they are very sharp[27].

+1	0
0	-1

0	+1
-1	0

Figure 6. Represents Robert Robert's mask

Operation Laplace

For a start, the LaPlace mathematical process must be clarified[28]:

$$^{2}F(x,y) = \frac{\delta^2 f(x,y)}{\delta\, x^2} + \frac{\delta^2 f(x,y)}{\delta\, y^2} \; - - - \rightarrow (1,2)$$

We note the Laplace given in equation (1,2). It is a continuous derivative of the second degree, the 100 types 3*3 Laplace mask used in processing digital images with transactions described in the form (1,-8). The LaPlace mask is not an oriented mask, so we do not control the direction and determine its characteristics. Therefore it has equal detail in all directions. It is essential to note that the slope or slope given to change the value of the point, and because of the mask laplace fixed rotation is an advantage in its favor because all directions are equal at the same time[29]. Thus we conclude that the disadvantages of the LaPlace mask are concentrated in the fact that it cannot determine the direction and is influenced by the presence of noise in the image to be revealed its edges[30].

0	1	0
1	-4	1
0	1	0

Figure 7. Represents the laplacianlaplas mask

COLLECTION OF DATA (IMAGES)

The tree (nature) and space images were collected from the internet (Google images). The third image is a personal photo, (figure 8 A, B, and C, respectively).

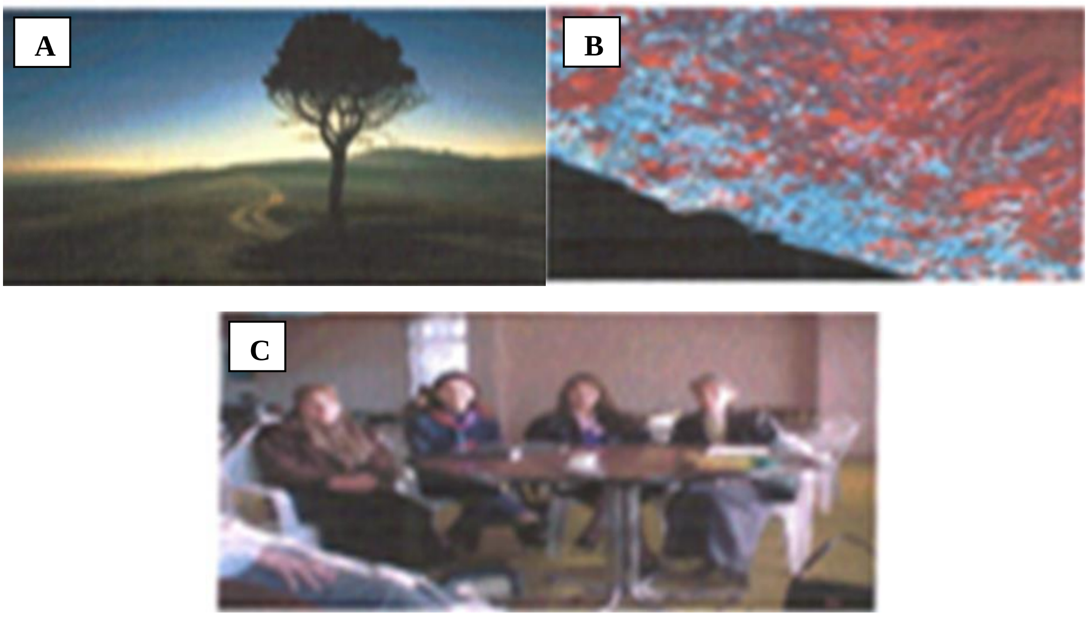

Figure 8. Images of the study. A. Tree, B. Space, and C. Personal.

METHOD OF EDGE DETECTION

This process is classified as directed and unguided types. Figure (3) represents the edge with its first and second derivative of it. We have used the subtlest of defining things and not separating things, and the goal of this process is to detect the colour changes in the image. This is about the application of programming methods using the Visual Basic 2019 program.

RESULT

Three different processes have been applied from edge detections to image elements as follows:

OPERATION SOBEL

Sobel process applied to the basic components and all elements of the image. The process was applied to all image (figure 9 A, B, and C).

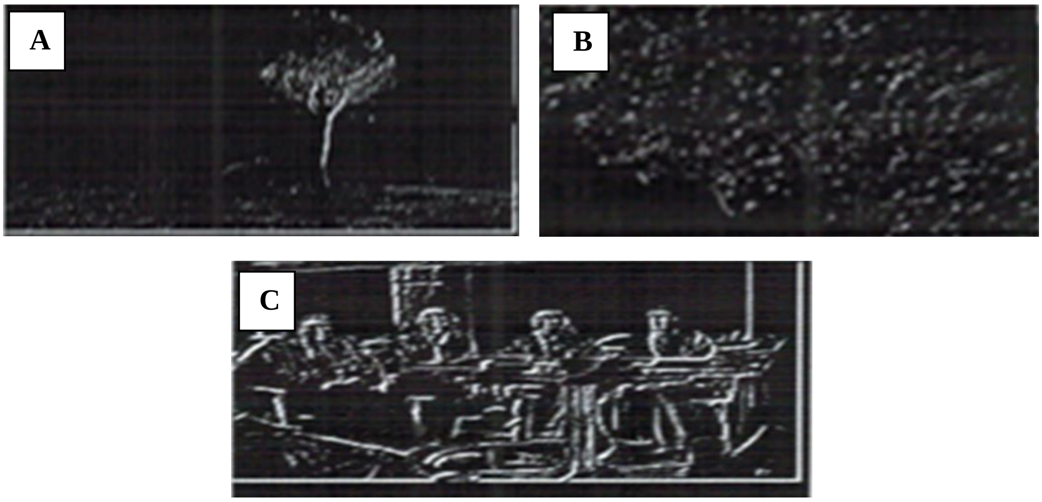

Figure 9. Images of the study processed by Operation Sobel. A. Tree, B. Space, and C. Personal.

OPERATION ROBERT

This process has been applied and the decline has been extracted in each direction; the values are integrated at each point and extraction of the total value. The advantages of this process are faster than other processes. The disadvantages are that it is sensitive to the noise in the image and the edges of the image must be sharp to be clear. Figure (10 A, B, and C) shows the results of this process on the profile picture, the results of the space and tree images are almost identical to Sobel and because its work depends on the same principle.

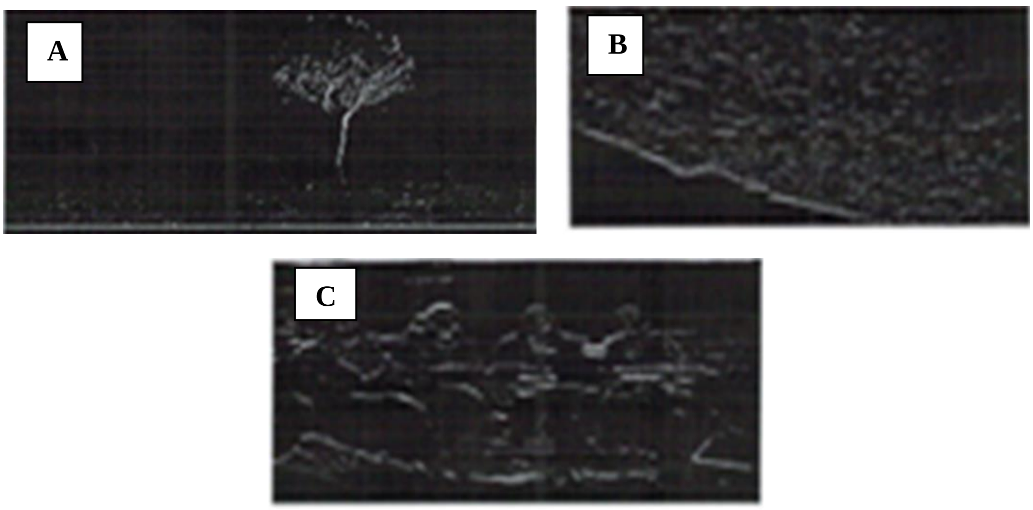

Figure 10. Images of the study processed by Operation Robert. A. Tree, B. Space, and C. Personal.

OPERATION LA PLACE

From the results (figure 11 A, B, and C), it could be seen that this process is weak to detect objects' edges because they depend on the second derivative. Some other techniques such as inclination or regression should be observed the value of the point, and usually, this method is used to see the point of what is located on the dark side or the light side.

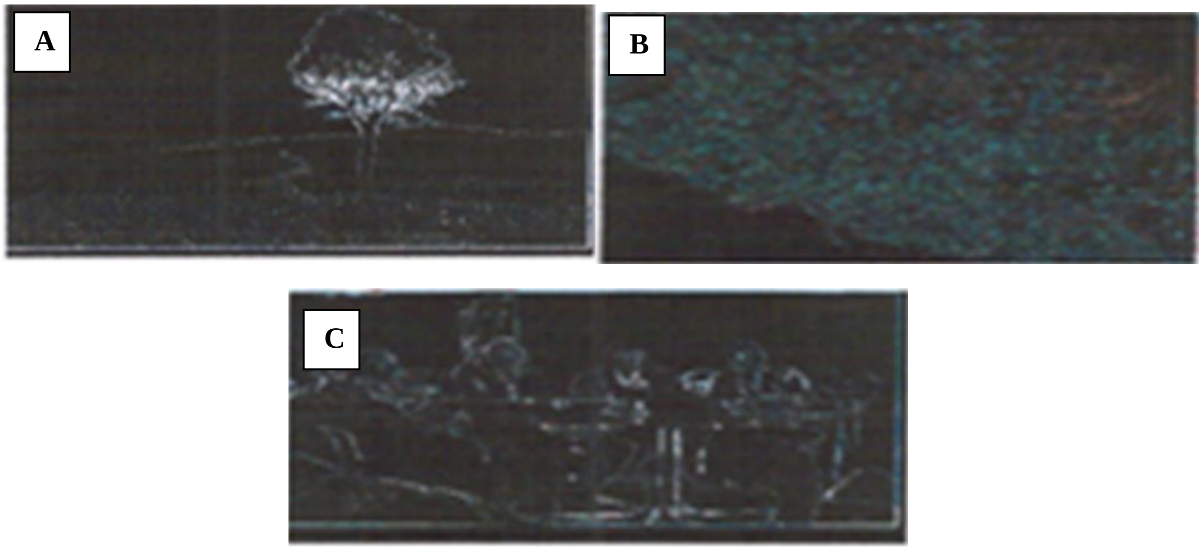

Figure 11. Images of the study processed by Operation La Place. A. Tree, B. Space, and C. Personal.

Edge detection is always one of the most classical studying projects of computer vision and image processing field. The fist step of image analysis and understanding is edge detection. The goal of edge detection is to recover information about shapes and reflectance or transmittance in an image. It is one of the fundamental steps in image processing, image analysis and computer vision, as well as in human vision. Edges detection applications vary between geographical images, topography , military , medical applications Etc. In this research, the three most important methods of detection of rims were programmed (Sobel method, Laplace method, Robert method), and we used colour images and grey images alongwith experiments were conducted to evaluate and the conclusion is described below.

CONCLUSIONS AND RECOMMENTATION

Since edge detection is the initial step in object boundary extraction and object recognition, it is important to know the differences between different edge detection operators. In this paper an attempt is made to review the edge detection techniques which are based on discontinuity intensity levels. The relative performance of various edge detection techniques is carried out with different images. We found that La Place gives better result as compared to Sobel and Robert's methods , as it highlights the contours of the shape more clearly and in addition to the fact that this method is faster than the other two. Robert's way is comparatively better than Sobel's method with aspect of performance and time. Quantisation was performed, and the edge detection process of the three approaches mentioned above was performed. We found a remarkable improvement in the output of these images compared to the original images. The time of execution of any operation is directly proportional to the size of the image to be processed. In grey images, the performance of all roads compared to colour images. I recommend applying the Laplace method to discover the edge of colored images because of its high clarity and accuracy

REFERENCES

[1] C. Solomon and T. Breckon, “Fundamentals of Digital Image Processing: A practical approach with examples in Matlab”, John Wiley & Sons, 2011.

[2] N.A.H.H.A. Naman, M.L. Al-dabag, and H. Salim, "Encryption System for Hiding Information Based on Internet of Things," International Journal of Interactive Mobile Technologies (iJIM), Vol. 15, No. 2, 2021.

[3] G.N. Hill, M.A.J.I.P. Whitty, and Management, "Embedding metadata in images at time of capture using physical Quick Response (QR) codes," Vol. 58, No. 3, Pp. 102504, 2021.

[4] L. Zhai, S. Dong, and H. Ma, "Recent methods and applications on image edge detection", In 2008 International Workshop on Education Technology and Training & 2008 International Workshop on Geoscience and Remote Sensing, Vol. 1, Pp. 332-335, 2008.

[5] J. Druzik, D. Glackin, D. Lynn, and R. Quiros, "The Use of Digital Image Processing to Clarify the Radiography of Underpainting. Journal of the American Institute for Conservation, Vol. 22, No. 1, Pp. 49-56, 1982. doi:10.2307/3179719

[6] M.E.J.B.A.I.J. Gonzalez, "Improving customer satisfaction of a healthcare facility: reading the customers' needs," 2019.

[7] M.J.P.A. Ahmed and Applications, "Reservoir-based network traffic stream summarization for anomaly detection," Vol. 21, No. 2, Pp. 579-599, 2018.

[8] A. Majumdar and B. Chaudhuri, "A MLP classifier for both printed and handwritten Bangla numeral recognition," in Computer Vision, Graphics and Image Processing: Springer, Pp. 796-804, 2006.

[9] S.C.J.I.T.O.C. Huang and S.F.V. technology, "An advanced motion detection algorithm with video quality analysis for video surveillance systems," Vol. 21, No. 1, Pp. 1-14, 2010.

[10] C.S. Lee and D.J.J.I. Therriault, "The cognitive underpinnings of creative thought: A latent variable analysis exploring the roles of intelligence and working memory in three creative thinking processes," Vol. 41, No. 5, Pp. 306-320, 2013.

[11] R.M. Al_airaji, I.A. Aljazaery, S.K. Al_dulaimi, and H.T.S. Alrikabi, "Generation of high dynamic range for enhancing the panorama environment," Bulletin of Electrical Engineering and Informatics, Article, Vol. 10, No. 1, Pp. 138-147, 2021.

[10] S.E. Umbaugh, "Computer vision and image processing: a practical approach using cviptools with cdrom", Prentice Hall PTR, 1997.

[12] S.S. Bhat, M. Hanumantharaju, and M. Gopalakrishna, "An Exploration on Various Nonlinear Filters to Preserve the Edges of a Digital Image in Spatial Domain," in Proceedings of the 2015 International Conference on Advanced Research in Computer Science Engineering & Technology (ICARCSET 2015), Pp. 1-7, 2015.

[13] J. Sjöbergh, "Detektionavsärdrag i bilderbaseradpåfärginformation", 2001.

[14] K. Messaoudi, H. Doghmane, H. Bourouba, E.B. Bourennane, S. Toumi, and M.C. Mssaadia, "Hardware/Software Implementation of Image Processing Systems Based on ARM Processor", In 4 th International Conference on Recent Advances in Electrical Systems, Pp. 78, 2020.

[15] A.E. Abdel-Hakim and A.A. Farag, "Color segmentation using an eigen color representation," in 2005 7th International Conference on Information Fusion, Vol. 2, Pp. 8, 2005.

[16] G. Raeder, "A survey of current graphical programming techniques", Computer, Vol. 18, No. 08, Pp. 11-25, 1985.

[17] C. Solomon, and T. Breckon, "Fundamentals of Digital Image Processing: A practical approach with examples in Matlab", John Wiley & Sons, 2011.

[18] I.A. Kakadiaris, G. Passalis, G. Toderici, M.N. Murtuza, Y. Lu, N. Karampatziakis, and T. Theoharis, "Three-dimensional face recognition in the presence of facial expressions: An annotated deformable model approach", IEEE Transactions on pattern analysis and machine intelligence, Vol. 29, No. 4, Pp. 640-649, 2007.

[19] P.M. Mather and M. Koch, "Computer processing of remotely-sensed images: an introduction", John Wiley & Sons, 2011.

[20] S. Naji, H.A. Jalab, and S.A.J.A.I.R. Kareem, "A survey on skin detection in colored images," Vol. 52, No. 2, Pp. 1041-1087, 2019.

[21] M. Al-dabag, H.S. ALRikabi, and R. Al-Nima, "Anticipating Atrial Fibrillation Signal Using Efficient Algorithm," 2021.

[22] B.J. AlKhafaji, M. Salih, S. Shnain, Z.J.P.o.E. Nabat, and N. Sciences, "Improved technique for hiding data in a colored and a monochrome image," Vol. 8, No. 2, Pp. 1000-1010, 2020.

[23] Y. Ou, J. Luo, B. Li, M.J.J.o.V.C. Swamy, and I. Representation, "Gray-level image denoising with an improved weighted sparse coding," Vol. 72, Pp. 102895, 2020.

[24] S.S. Al-Amri, N.V. Kalyankar, and S.D. Khamitkar, "Image segmentation by using edge detection", International journal on computer science and engineering, Vol. 2, No. 3, Pp. 804-807, 2010.

[25] M. Juneja, and P.S. Sandhu, "Performance evaluation of edge detection techniques for images in spatial domain", International journal of computer theory and Engineering, Vol. 1, No. 5, Pp. 614, 2009.

[26] H. Pan, L. Qi, Z. Zhang, and J. Yan, "Kinetic energy harvesting technologies for applications in land transportation: A comprehensive review", Applied Energy, Vol. 286, Pp. 116518, 2021.

[27] J.M. Graving, D. Chae, H. Naik, L. Li, B. Koger, B.R. Costelloe, and I.D. Couzin, "DeepPoseKit, a software toolkit for fast and robust animal pose estimation using deep learning", Elife, Vol. 8, Pp. e47994, 2019.

[28] B. Chaput, J.C. Girard, and M. Henry, "Frequentist approach: Modelling and simulation in statistics and probability teaching", In Teaching Statistics in school mathematics-Challenges for teaching and teacher education, Pp. 85-95, 2011.

[29] S.I.M. Team, "MPAS-Ocean User's Guide", 2018.

[30] E.M. Haacke, S. Liu, S. Buch, W. Zheng, D. Wu, and Y. Ye, "Quantitative susceptibility mapping: current status and future directions", Magnetic resonance imaging, Vol. 33, No. 1, Pp. 1-25, 2015.